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JAMAICA'S SCIENTIFIC RESEARCH COUNCIL : ITS ROLE IN THE DEVELOPMENT OF A MINERAL INDUSTRY PROGRAMME

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JAMAICA'S SCIENTIFIC RESEARCH COUNCIL ITS ROLE IN THE DEVELOPMENT OF A MINERAL INDUSTRY PROGRAMME

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INTRODUCTION

The Scientific Research Committee, recognising the important contribution that a healthy mineral industry can make to the national economy, organised the Geochemistry Unit as its first wholly supported research group. The duties of this group were to undertake and foster research in those areas of the country's mineral industry programme not then covered by the activities of the Geological Survey Department, Mines Department and the mining companies. It was felt that such a group assessing the information available on our minerals, and supplementing it with new data, could contribute to the evaluation of mining prospects, and so assist the country in the negotiation of new mining contracts, and the exploitation of our mineral resources. The Scientific Research Council, the successor of the Committee, endorsed the terms of reference of the Unit and appointed an Advisory Board to direct its general research programme.

2. Initially water quality research was given first priority because an adequate supply of water of satisfactory quality is basic to the industrialization of the country and is an important factor in environmental health. The country is also committed to a programme of public water supply development, and basic water quality data are vital to the proper design and maintenance of these schemes. The Ministries of Health and Local Government, and the Geological Survey Department collaborated in this programme.

3. The Unit was also interested in economic minerals. The principal emphasis in the ore minerals research programme has been on low-cost, large-tonnage materials in the development of which Jamaica has been singularly successful. Such an approach highlights the utilization of the minerals that are known to occur, in preference to organised search mainly for minerals which are in short supply on the world market and so command premium prices. The fine grained minerals (clays and bauxite) are economically the most important, contributing over Thirty-three Million Pounds of the national economy (Central Planning Unit Report, 1961). Other important minerals are gypsum, glass sands, and marble. The large scale exploitation of our limestone deposits which are extremely pure and cover at least two-thirds of the surface of the island, offer potential which could be economically important (Zans et al, 1962, p. 26). Limestone could be utilized in the manufacture of high quality lime for use in the sugar industry, the preparation of bordeaux mixture, the manufacture of calcium carbide, and in the building industry in plasters, mortars etc.

BAUXITE AND CLAYS

4. The principal minerals in the local bauxite are gibbsite $Al(OH)_3$,

which may account for over eighty percent of the ore in a few cases, but usually averages about seventy percent; boehmite ($AlO.OH$), which is sometimes a minor constituent but may be as abundant as twenty percent; kaolinite and halloysite[1] $Al_2Si_2O_5(OH)_4$. The iron oxide content is between eighteen and twenty-five percent, and the particle size is so small that it coats the other minerals and makes it difficult to determine in which mineral species it is present. Quartz and chert occur in the size range of sand to clay, but the distribution of the sand range is erratic, and the fine grained sizes occur in areas where the clay mineral content is high but variable. Titanomagnetite and illmenite are present to a minor extent (Hill, 1955, p. 680-82). Minor amounts of tourmaline, garnet and volcanic glass have been reported (Hartman, 1955, 25-26).

5. The extraction characteristics of the alumina from the ore by a Bayer type process are dependent on the gibbsite-boehmite content. It is more difficult to extract alumina from boehmite than from gibbsite, and the kaolin minerals use up caustic soda. The rate of reaction of quartz with caustic soda, although dependent on particle size is slow, and so like the iron oxide it is inert in a Bayer process. It is therefore desirable that the method for grading bauxite should attempt to determine the gibbsite, boehmite, kaolin, and quartz content rather than the gross content of the different oxides. Such a scheme may permit us to delineate areas of high boehmite content and so consider the feasibility of using higher pressure digestion methods on these ores. It may also show that ore now classified as low grade (on the basis of the silica content) may actually be of a higher grade because the silica is present as quartz. A chemical method which may be of value in such a scheme of grading was developed by the Unit (Hill and Price 1962). This method is rapid and is based on the relative solubility of gibbsite, boehmite, kaolin and quartz in a fifty percent caustic soda solution. Alumina is determined on the filtrate complexometrically with E.D.T.A. and silica colourimetrically as the molybdosilicate. Attempts are also being made to use differential thermal analysis techniques to determine the mineral content.

6. The logical extension of this programme of work is the investigation of the mineral composition of our low grade bauxite and other laterites to classify them as aluminium ore, or as high alumina clays for the manufacture of refractories.

7. An investigation which resulted in the location of a small but important deposit of high quality non-plastic kaolin provides an excellent example of what can be achieved through collaboration. The original find was made because the Mines Department submitted a mineral specimen for identification. The differential thermal analysis pattern of the sample was like that of kaolin except that the 580°C and 950°C peaks are doublets. X-ray diffraction analysis of the samples at the Geochemistry Department of the Pennsylvania State University, Overseas Geological Survey and the Kaiser Research Laboratories confirmed that the sample was well ordered kaolinite with possibly some dickite. Table I gives the X-ray diffraction data of the specimen.

TABLE I: Lattice Spacings of Kaolin Mineral From Job's Hill

d-value	Relative Intensity	d-value	Relative Intensity
4.46 a.u.	W	3.51 a.u.	W
4.39	W	3.44	W
4.26	W	3.35	W
4.14	M	2.57	M
3.98	W	2.51	M
3.82	W	2.395	S
3.62	S	2.332	S

W = weak; M = medium; S = strong.

(1) The state of hydration has not been determined.

The chemical analysis of the minor constituents of the sample is given in Table II.

TABLE II: Minor Constituents in Job's Hill Kaolin

	M.R.D.(1)	S.R.C.
Fe_2O_3	0.18	-
K_2O	0.07	0.14
Na_2O	0.19	0.62

(1) Mineral Resources Division, Overseas Geological Surveys.

Samples were submitted to Jamaica Potteries Limited, to determine if this material was suitable for blending with the local plastic kaolin, found at Frenchman's Cove, to produce a body which was white firing, and adaptable to the process in their plant. The results of these tests are encouraging.

8. Field examination of the Job's Hill area (where the mineral occurred) carried out in collaboration with Mr. D.L. Cooke of the Geological Survey Department showed that the rocks consist of andesite, trachyte lavas, andesitic conglomerates, and greywaches. The lavas contain horizons of glassy tuffs which change to kaolin where it is hydrothermally altered. Petrographic examination by Mr. Cooke shows the following sequence of alteration, (i) devitrification of welded glass to a granular feldspathic aggregate, (ii) kaolinization of this aggregate to a semi-opaque mass, (iii) hydrothermal alteration causing recrystallization to a partially cloudy mineral and migration of the iron oxide, (iv) development of a clear crystalline clay mineral.

9. The preliminary results suggest that this clay may be used for blending with Frenchman's Cove clay, and so replace material currently imported. The investigation is therefore continuing to determine if sufficient tonnage of this material exists.

IRON ORES

10. The possibility of setting up an iron industry in Jamaica using scrap iron, iron ores, and bauxite red mud tailings is of vital interest because of the role that this industry could play in the development of the island. Such an industry would have its roots in the rural areas and so would supplement agriculture and provide a basic raw material that is now imported. Table III shows the amount of easily fabricated products imported into the island. Work on this project is in its early stages but there are indications that by blending the magnetite from the black sands which occur along the south coast, with the magnetite-hematite ore from Mavis Bank, St. Andrew (Perelli, 1962; Zans,1951) and dehydrated bauxite red mud it may be possible to establish sufficient ore reserves to warrant the operation.

11. Three dune-like occurrences of black sand have been located on the south coast by the Geological Survey Department and a mining company. These sands are fairly well sorted over 90% of the grains having a diameter less than 60 mesh (B.S.S.) but greater than (200 mesh). There are however zones where the minus 200 mesh fraction may be as high as fifteen percent. The sand deposits contain between twelve and thirty percent magnetic minerals. The sorting of the sands in these zones is less than in the black sands, but the magnetic content is between fifteen and twenty percent. The outer surface of each deposit contains a much higher percentage of magnetite than the rest of the deposit. The most magnetic fraction is composed principally of titaniferous magnetite with exsolved hematite and contains 60% Fe, and 14% TiO_2.

TABLE III

IMPORTS INTO JAMAICA OF CERTAIN BASE METALS DURING 1952-61

IRON & STEEL BAR	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Quantity in tons	4,440	(1) 2,896	3,675	8,800	10,874	14,412	10,398	11,945	14,686	15,090
Value in £	295,989	133,131	140,020	411,692	474,493	761,869	451,164	465,163	626,132	633,121
PIG & SPONGE IRON (2)										
Quantity in tons	41	-	67	53	54	64	52	87	102	112
Value in £	1,285	-	2,104	1,984	1,618	2,437	1,796	3,090	3,871	5,170

(1) Iron Bars only

(2) Including iron and steel powder.

(Information supplied by Department of Statistics).

12. A preliminary estimate of the sand available in the area indicates the presence of approximately eight million tons of sand, containing at least fifteen percent magnetite. It is therefore possible to produce about one million tons of concentrate.(1)

13. The bauxite red mud tailings contain over forty-five and often as much as sixty percent Fe_2O_3 and between five and eight percent of titanium. The particle size of this material is in the sub-micron range and so the surface area is extremely large and it often dehydrates with the rapid evolution of gasses and creates handling problems. It is however possible that if the ore from the three sources (Mavis Bank ore, beach sand concentrate, and bauxite red mud-tailings) are blended the mixture may be suitable for smelting. The objectionable high titanium content of the ore from beach sand concentrate may also be overcome by this type of blending.

GEOCHEMICAL PROSPECTING

14. The Unit has also conducted a geochemical prospecting survey for nickel in the Blue Mountain area and has assessed geochemical prospecting data for copper in the possession of the Mines Department (Hill 1961, 1962).

15. The former project was undertaken at the request of the Geological Survey Department which had found evidences of nickel bearing serpentine near Cedar Valley in St. Thomas foothills of the Blue Mountain range. The survey confirmed that nickel is associated with the presence of bronzite phenocrysts in the serpentinized intrusive. The nickel preferentially substitutes in the magnetite structure but some of it is also present as nickelion serpentine. The concentration of nickel in the anomalous areas is between 0.2 to 0.3 percent. No evidence was found of any concentration of nickel in laterites probably because magnetite is extremely resistant to weathering and also because the terrain is too rugged to allow the accumulation of a laterite. The observed concentration of nickel is within the range considered normal for ultrabasic rocks, suggesting that it is within this facies of the intrusive that the nickel is found, and the anomalous area outlined delineates this zone.

16. Statistical methods were used to evaluate the above geochemical prospecting survey data, and that obtained during a search for copper in the Bellas Gate area, Clarendon, by Jamaica Copper and Iron Limited. It is believed that this approach is particularly useful in areas where geochemical prospecting is applied without a background of information on the threshold value for the diagnostic element or radical. The approach is to plot the log concentration of the diagnostic element as a cumulative frequency curve, and derive the unique frequency curve for the distribution by differentiating it. If the resultant unique frequency curve is unimodal, it is unlikely that an anomalous zone exists. However, if the curve is polymodal then an anomalous area exists, and the data should be plotted to delineate it. The technique cannot determine if an ore body exists. It locates only an anomalous area, and further field observation is necessary to make this distinction. Its value lies in its reduction of the size of the target.

WATER QUALITY AND WASTE DISPOSAL RESEARCH

17. Water being the most important mineral in the economy of a developing country, particular emphasis was placed on the investigation of the chemical composition of the surface and sub-surface water of the island. In some instances, the seasonal variations in the composition of these waters have been found to be great and indicative of pollution. This was particularly so in the Pedro Plains. The evidence so far available suggests that pollution of the sub-surface waters by seepage from human and animal refuse is a serious problem, and that the abnormal potassium content of the water from several wells can be used as an index of this pollution. (Hill and Ellington 1962). The Unit's investigation disclosed that the intrusion of sea water into the sub-surface water of the Clarendon Plains is creating a problem to which a solution must be found (Hill and

(1) Personnel Communication, from Chief Engineer to the Mining Company.

Ellington, 1961).

18. Another factor which has been examined is the calcium carbonate stability of water. This has an important bearing on the design and maintenance of water supply schemes, and is also of interest in the building and construction industry. The lime scaling of pipes in public water supply projects has presented a very serious problem because the carrying capacity of pipes is often reduced to the extent where it becomes necessary to by-pass the storage reservoir and pump the water directly into the supply mains. The result is that it is often necessary to run these pumps continually, a procedure which reduced their operational life. In addition, it has been observed that where the water used to mix concrete is supersaturated with respect to calcium carbonate the resultant product has a reduced compression strength. This decrease in strength may be due to the deposition of finely divided lime on the aggregates and as veinlets in the matrix.

19. A programme of work for the routine determination of calcium carbonate stability of water samples was started. The indications are that in limestone areas the wells or rivers at their sources are prone to become meta-stable with respect to calcium carbonate. River or well water in other areas are in stable equilibrium with respect to calcium carbonate. This work is still in progress (and will be reported on more fully in the future).

20. The disposal of rum distillery slop in areas where it it not possible to incorporate it in irrigation water or empty it into the ocean has always posed a difficult problem. The emptying of large quantities of this waste directly into the river has been reported to cause the death of fish. Table IV gives some basic data for fresh rum distillery slop.

TABLE IV: Typical Data for Rum Distillery Slop

Property	Value
pH	4.2
Colour	dark brown and opaque
C.O.D.	72,800 mg/l O_2
Acidity	3,530 mg/l H_2SO_4
Na	150 mg/l
K	11,200 mg/l

21. Attempts at purification by chemical means and absoprtion have not proved feasible. Work by the Unit has, however, indicated that it may be practicable to dispose of it by careful dilution with ordinary river water followed by aeration. It has also been established that the immediate cause of observed death of the fish was the depletion of the oxygen in the water. As a result of this, a series of experiments were designed to determine the rate of depletion of the dissolved oxygen in river water containing different concentrations of slop. Figure I gives a typical series of curves showing these curves. All these curves show a lag period of about twenty-four hours during which there is little change in the dissolved oxygen. However, the rate of depletion from then onwards was different, decreasing with increasing dilution. The colour, turbidity and chemical oxygen demand of the diluted slop have a simple linear relationship to the degree of dilution and do not appear to be objectionable at dilutions greater than (1:1000). The acidity is neutralized by the bicarbonate present in the diluting water when the dilution is greater than about (1:200). The work to date suggests that

the disposal of the slop into a river can satisfactorily be accomplished by a simple dilution and aeration treatment provided that the mixing is adequate.

22. It has been determined that in dilutions of about (1:1600) the slop if saturated with air will maintain an oxygen balance after several days of anaerobic storage at 20°C. However, it still has to be demonstrated conclusively that there are no undesirable side effects associated with such a scheme.

ACKNOWLEDGMENTS

23. The research reported was entirely supported by the Scientific Research Council of Jamaica. The author would like to express his thanks to the members of the Geochemistry and Water Quality Advisory Boards for their interest and assistance in all phases of the programme.

24. The co-operation of the staff of the Geological Survey Department, Water Supplies Branch of the Ministry of Local Government and Sanitary Engineering Bureau of the Ministry of Health in the field investigations is gratefully acknowledged. The Department of Government Chemist provided both laboratory space and assistance for this work.

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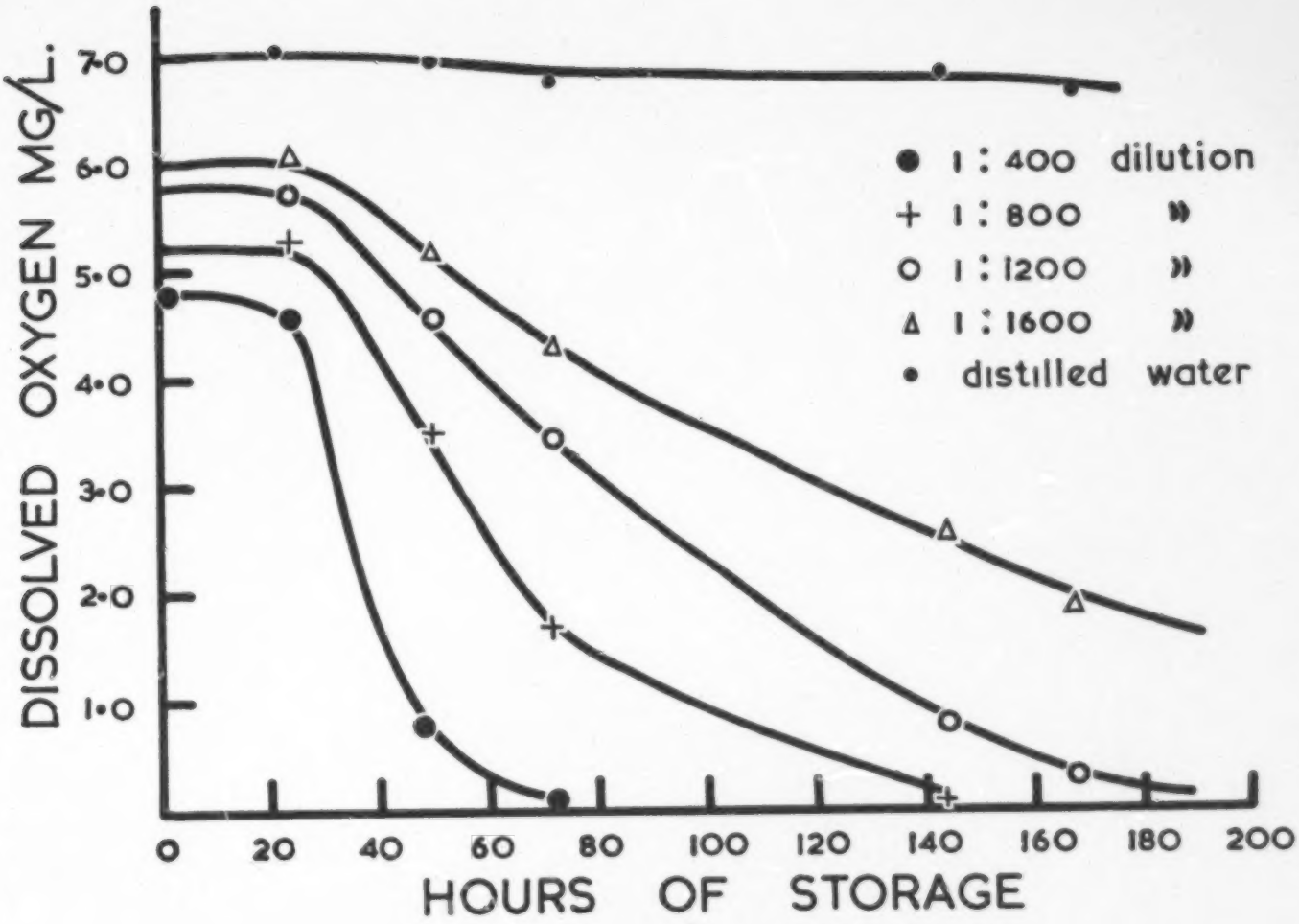

Figure I: Graph showing typical rate of depletion of the dissolved oxygen content of rum distillery slop diluted with river water.

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